
एविएशन टर्बाइन ईंधन,
मिट्टी के तेल के प्रकार,
जेट-ए-1 — विशिष्टि

(दसवां पुनरीक्षण)

Aviation Turbine Fuels,
Kerosine Type, Jet-A-1 —
Specification

(Tenth Revision)

ICS 75.160.20

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FOREWORD

This Indian Standard (Tenth Revision) was adopted by the Bureau of Indian Standards, after the draft finalized by the Petroleum and their Related Products of Synthesis or Biological Origin Sectional Committee had been approved by the Petroleum, Coal and Related Products Division Council.

This standard was first published in 1960 and subsequently revised in 1965, 1967, 1976, 1982, 1985, 1992, 2001, 2008 and 2017.

The tenth revision of this standard is a result of a review of the standard in light of the present day requirements of the products and in order to align it with British Ministry of Defence specification DEF STAN 91-091 (Issue 9, 03 October 2016). Assistance has also been derived from ASTM D 1655-18a 'Standard Specification for Aviation Turbine Fuels and Aviation Fuel Quality Requirements for Jointly Operated System' (AFQRJOS-Issue 29 – Oct 2016).

The need for International Coordination among recognized standard of other countries on the subject is particularly significant for the product of this type since re-fueling of aircraft in different countries is often involved.

The approved additive systems, namely, antioxidants, metal deactivators (MDA), static dissipater additive (SDA), lubricity improver additive (LIA) and fuel system icing inhibitor (FSII), have been adopted from DEF STAN 91-091 (Issue 9).

Experience has shown that refinery processing additives, such as corrosion inhibitors, might be carried over in trace quantities into aviation fuel during refinery production. In some cases, this has resulted in operational problems in aircraft fuel systems. Moreover, these additives can cause problems at levels which may not be detected by the standard specification testing as given in Table 1. It is stated in 3.2 that non-approved additives are not permitted but it is not straightforward to define a zero level, although it is accepted that;

- a) modern analytical techniques are capable of detecting extremely low levels of chemical species,
- b) there could be a wide range of materials involved, and
- c) in most cases there are no data on their effects in aircraft systems to define a no-harm level.

It is, therefore, not practical for this standard to require detailed chemical analysis of each production batch of aviation fuel beyond the requirements listed in this standard. Instead, it is recommended that manufacturing locations ensure that they have adequate quality assurance and management of change procedures in place to ensure that refinery processing additive used is well defined and controlled. Any changes in additive composition/manufacturing source or refinery processing conditions should be subject to a formal risk assessment to ensure maintenance of finished product quality. Information on quality assurance of fuel is given in Annex E.

Reference to other overseas standards like ISO, ASTM, IP etc has been given for few parameters, as presently there is no Indian Standard available for them. Once the Indian Standards are formulated, the references will be modified accordingly. The alternate test methods are provided in Annex G for the characteristics stated and in case of dispute the referee method shown in the Table 1 shall be followed.

For the purpose of deciding whether a particular requirement of this standard is complied with the final value, observed or calculated, expressing the result of a test or analysis shall be rounded off in accordance with IS 2 : 1960 'Rule for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Indian Standard

AVIATION TURBINE FUELS, KEROSENE TYPE, JET-A-1 — SPECIFICATION

(Tenth Revision)

1 SCOPE

1.1 This standard prescribes requirements and the methods of sampling and test for one grade of kerosene type, aviation turbine fuels, Jet A-1, used in appropriate aircraft fitted with turboprop or Jet engines.

1.2 This standard does not purport to address all of the safety problems associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

2 REFERENCES

The standards listed below contain provisions which, through reference in this text, constitute provisions of this standard. At the time of publication the editions indicated were valid. All standards are subject to revision, and parties to agreements based on the standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below:

<i>IS No.</i>	<i>Title</i>	<i>IS No.</i>	<i>Title</i>
1260 (Part 1) : 1973	Pictorial marking for handling and labeling goods: Part 1 Dangerous goods	[P : 18] : 1991	Distillation of petroleum products
1447 (Part 1) : 2000	Petroleum and its products — Methods of sampling: Part 1 Manual sampling	[P : 19] : 2015/ ISO 5275 : 2003	Detection of thiols and other sulphur species — Doctor test (<i>second revision</i>)
1448	Methods of test for petroleum and its products	[P : 20] : 1998	Determination of flash point by Abel apparatus
[P : 3] : 2007/ ISO 2977 : 1997	Aniline point	[P : 23] : 2004/ ISO 3837 : 1993	Liquid petroleum products — Determination of hydrocarbon types — Fluorescent indicator adsorption method
[P : 6] : 1984	Calorific value by bomb calorimeter method	[P : 25] : 1976	Determination of kinematic and dynamic viscosity
[P : 11] : 2004/ ISO 3013 : 11997	Petroleum products — Determination of freezing point of aviation fuels	[P : 29] : 2004/ ISO 6246 : 1995	Petroleum products — Gum content of light and middle distillate fuels — Jet evaporation method
[P : 15] : 2004/ ISO 2160 : 1998	Petroleum products — Corrosiveness to copper — Copper strip test	[P : 31] : 2017	Smoke point (<i>first revision</i>)
[P : 16] : 2014/ ISO 3675 : 1998	Density of crude petroleum and liquid petroleum products by hydrometer method	[P : 34] : 1979	Determination of sulphur in petroleum products (lamp method)
		[P : 42] : 2015/ ISO 6250 : 1997	Determination of the water reaction of aviation fuels (<i>third revision</i>)
		[P : 97] : 2015/ ISO 6249 : 1999	Determination of thermal oxidation stability of gas turbine fuels — JFTOT method (<i>first revision</i>)
		[P : 109] : 2004/ ISO 3012 : 1999	Petroleum products — Determination of thiol (mercaptan) sulphur in light and middle distillate fuels
		[P : 113] : 1983	Determination of total acidity of aviation turbine fuels (ATF)
		[P : 118] : 1985	Naphthalene hydrocarbons in aviation turbine fuels by UV spectrophotometry
		[P : 142] : 1993	Determination of water separation characteristics of aviation turbine fuels by portable separometer

3 REQUIREMENTS

3.1 General

The material shall be clear, bright and free from sediment, suspended matter and undissolved water at normal ambient fuel temperature.

3.2 Composition

Jet fuel is a complex mixture of hydrocarbons that varies depending on crude source and manufacturing process. Consequently, it is impossible to define the exact composition of jet fuel. This specification has therefore evolved primarily as a performance specification rather than a compositional specification. It is acknowledged that this largely relies on accumulated experience; therefore the specification limits jet fuels to those made from conventional sources.

The fuel shall consist completely of hydrocarbon compounds derived from conventional sources including crude oil, natural gas liquid condensates, heavy oil, oil shale and oil sands and the qualified additives specified below.

3.2.1 Antioxidants

An approved antioxidant or mixture of antioxidants shall be added to a fuel (or a fuel component) which has been hydro processed (that is manufactured using a catalytic hydrogen process such as hydrotreating, hydrofining, hydrocracking, etc). This addition is to prevent peroxidation and gum formation, the point of anti-oxidant addition shall be before or during release from the manufacturing site. The total concentration of active material(s) in fuel or that proportion of the fuel blend that has been hydroprocessed shall not be less than 17.0 mg/l nor exceed 24.0 mg/l. Where a finished fuel comprises a blend of hydroprocessed and nonhydroprocessed components, the requirements for mandatory addition of antioxidant applies only to that portion of the blend which has been hydroprocessed. In such cases the proportion of the blend which has been hydroprocessed shall be reported.

NOTE — If fuel is certified before the addition of antioxidant, the certificate of quality should be annotated thus, "Product meets the requirements of IS 1571, except for Antioxidant, which will be added prior to product leaving the manufacturing location.

For fuel (fuel component) which has not been hydro-processed such addition is optional. However, the total concentration shall not exceed 24.0 mg/l and shall be reported on the certificate of quality.

Where a fuel, or a blend component of the fuel, has been hydro processed or severely hydro processed, the concentration of active material added to these portions of the blend shall be reported on the certificate of quality. If antioxidant has also been added to the non-hydro processed portion of the fuel the concentration of active material added to this portion should be reported on the separate line on the certificate of quality.

The following are some of the approved antioxidants:

<i>Formulation</i>	<i>Qualification Reference</i>
(a) 2,6-ditertiary-butyl-phenol	RDE/A/606
(b) 2,6 ditertiary-butyl-4-methyl-phenol	RDE/A/607
(c) 2,4-dimethyl-6-tertiary-butyl-phenol	RDE/A/608
(d) A mixture consisting of 75 percent minimum, 2,6 ditertiary-butyl-phenol; 25 percent maximum, tertiary and tritertiary-butyl-phenols;	RDE/A/609
(e) A mixture consisting of 55 percent minimum, 2,4-dimethyl-6-tertiary-butyl-phenol; 15 percent minimum, 4 methyl-2,6 ditertiary-butyl-phenol; with the remainder, 30 percent maximum, as a mixture of monomethyl and dimethyl-tertiary-butyl-phenols; and	RDE/A/610
(f) A mixture consisting of 72 percent minimum, 2,4-dimethyl-6-tertiary-butyl-phenol; 28 percent maximum, mixture of tertiary-butyl-methyl-phenols and tertiary-butyl-dimethyl-phenols	RDE/A/611

NOTE — The concentration of antioxidant added to the fuel should be reported as follows:

1 Report the total antioxidant addition as an equivalent concentration of active material in the proportion of the final batched fuel that comprises hydro processed, severely hydro processed, non- hydro processed and/or synthetic blend components on the certificate of quality.

2 Report the total active material concentration in the final batched fuel on the Refinery Certificate of Quality.

3 If the antioxidant is added during ship loading the reporting requirements shall be the same as those in 1 and 2 above.

3.2.2 Metal Deactivator Additive (MDA)

An approved metal deactivator, N, N'-disalicylidene1, 2-propanediamine, may be added in amount not exceeding 2.0 mg/l on initial batching of the fuel at the refinery and 5.7 mg/l on cumulative addition when redoping the fuel to counteract the effects of metals known to be deleterious to thermal stability such as copper (Cu), cadmium (Cd), cobalt (Co), iron (Fe) and zinc (Zn) provided that the nature of the contamination is reported. Where metallic

contamination is unproven, MDA may be used to recover thermal stability provided that JFTOT Test [in accordance with SI No. (vii) of Table 1] is determined before and after MDA addition and reported on the test certificate.

<i>Product</i>	<i>Qualification Reference</i>
N,N'-disalicylidene 1,2-propanediamine	RDE/A/650

3.2.3 Static Dissipater Additive (SDA)

3.2.3.1 Wherever necessary, a qualified SDA shall be added to the fuel to impart electrical conductivity in accordance with property SI No. (x) of Table 1.

3.2.3.2 The concentrations in which SDA is to be added to the fuel are as follows:

- The concentration of SDA to be used in newly manufactured, or on first doping of fuel is 3.0 mg/l maximum.
- The cumulative concentration of SDA allowed when re-doping fuel to maintain conductivity is 5.0 mg/l maximum.

NOTE — A suitable method for the determination of SDA 450 concentration at the point of manufacture is IP 568 or ASTM D7524.

<i>Formulation</i>	<i>Manufacturer</i>	<i>Qualification Reference</i>
Stadis® 450	Innospec LLC	RDE/A/621
Av Guard SDA	Afton Chemicals	RDE/A/DSFA/001

3.2.4 Lubricity Improver Additive (LIA)

3.2.4.1 A qualified LIA may be added to the fuel to impart improved lubricity to the fuel.

NOTE — Further information on aviation turbine fuel lubricity is available at Annex A.

3.2.4.2 Because LIA exists in equilibrium with metal surfaces of fuel distribution systems as well as those of aircraft systems, correct delivery to aircraft can be assured only by equilibration of the supply system downstream of the LIA addition or by additive injection at the point of entry to the aircraft.

NOTE — Some of the qualified lubricity improving additives along with their concentration in which they are added to the fuel at the time of delivery to the purchaser are as follows:

<i>Product</i>	<i>Manufacturer</i>	<i>Qualification Reference</i>	<i>Minimum mg/l</i>	<i>Maximum mg/l</i>
Hitec 580	Afton Chemical Ltd.	RDE/A/661	15	23
Octel DCI-4A	Innospec LLC	RDE/A/662	9	23

<i>Product</i>	<i>Manufacturer</i>	<i>Qualification Reference</i>	<i>Minimum mg/l</i>	<i>Maximum mg/l</i>
Octel DCI-6A	Innospec LLC	RDE/A/663	9	15
Nalco 5403	Nalco Chemical Co.	RDE/A/664	12	23
Tolad 4410	Baker Petrolite	RDE/A/665	9	23
Tolad 351	Baker Petrolite	RDE/A/666	9	23
Unicor J	DorfKetal Chemicals	RDE/A/667	9	23
Nalco 5405	Nalco Chemicals Co	RDE/A/668	11	23
Spec Aid 8Q22	GE Betz	RDE/A/669	9	23

3.2.5 Fuel System Icing Inhibitor (FSII)

3.2.5.1 A qualified FSII may be added to the fuel as agreed to between the purchasing authority and the supplier. Concentrations less than 0.02 percent by volume can be considered negligible and do not require agreement/notification. The assent to allow these small quantities of FSII without agreement/notification is to facilitate the changeover from fuels containing FSII where the additive may remain in the fuel system for a limited time. Under no circumstances is this background level allowed in fuel that is to be delivered through a filter monitor. This does not allow the continuous addition of FSII at these low concentrations.

3.2.5.2 Under no circumstances shall fuels containing FSII be delivered through a filter monitor.

3.2.5.3 The following material is qualified at the specified concentration mentioned below:

<i>Product</i>	<i>Concentration</i>	<i>Qualification Reference</i>
Di ethylene Glycol Mono methyl Ether (DGME)	Not less than 0.1 percent and not more than 0.15 percent by volume	RDE/A/630

NOTES:

1 When LIA (*see* 3.2.4) and FSII (*see* 3.2.5) are to be used together, it may be found convenient to add the LIA in admixture with FSII. Whatever blending procedure is adopted, the supplier shall satisfy the purchaser that the correct concentration of LIA has been incorporated homogeneously. The supplier shall record the concentration of LIA and the information on the additives added shall be provided to the customer.

2 The material shall be added, where mandated, at a concentration of not less than 0.10 percent and not more than 0.15 percent by volume at the time of delivery to the purchaser. Suitable methods for determining the additive concentration are IP 424 and ASTM D 5006.

3.2.6 Warning

The addition of LIA to the fuel containing an SDA may further affect the electrical conductivity and MSEP of the fuel. Fuel containing SDA only or both of these types of additives shall comply with the appropriate requirements stated in Table 1 for electrical conductivity and MSEP unless agreed otherwise between the purchasing authority and the supplier.

3.2.7 Leak Detection Additive

3.2.7.1 Where necessary a leak detection additive may be added to the fuel to assist in detecting and locating leaks in ground based fuel storage, delivery and dispensing systems. It should be recognized that other leak detection techniques may have less environmental impact than Tracer A. The additive should only be used when other options have been considered.

3.2.7.2 The following material is qualified:

<i>Product</i>	<i>Concentration</i>	<i>Qualification Reference</i>
Tracer A (LDTA-A)	Tracer Research Corporation	RDE/A/640

3.2.7.3 The concentration of Tracer A shall not exceed 1.0 mg/kg.

3.3 The material shall also comply with the requirements prescribed in Table 1 when tested with test methods mentioned in col 4 of Table 1.

4 SAMPLING

4.1 Representative samples of material shall be drawn as prescribed in IS 1447 (Part 1).

4.2 Representative samples of each batch of the product shall be tested to prove homogeneity. On proving homogeneity, all characteristics given in the standard shall be tested on composite sample prepared by mixing representative samples, proportionately.

4.3 The lot shall be declared as conforming to the requirements of the standard, if all the test results on the composite sample meet relevant standard requirements.

5 PACKING AND MARKING**5.1 Packing**

The material shall be packed in suitable containers as agreed to between the purchaser and the supplier subject to relevant rules and regulations in force in the country.

5.2 Marking

The material shall be supplied in accordance with the marking and delivery instructions given by the purchaser.

5.2.1 Each container shall be marked with the following information:

- Name and grade of the material;
- Indication of the source of manufacturer, initials or recognized trade-mark, if any;
- Volume of the contents, in litres;
- Year and month of manufacturing or packing; and
- Any other statutory requirements.

5.2.2 Each container shall also be marked with the caution label 'Highly Flammable' together with the corresponding symbol for labelling dangerous goods [see IS 1260 (Part 1)].

5.2.3 BIS Certification Marking

The container may also be marked with the Standard Mark.

5.2.3.1 The use of Standard Mark is governed by the provisions of the *Bureau of Indian Standards Act, 2016* and the Rules and Regulations made there under. The details of the conditions under which the licence for use of the Standard Mark may be granted to manufacturers or producers may be obtained from the Bureau of Indian Standards.

5.3 Handling and Storage

For the safe handling and storage of the fuel the instructions given in Aviation Quality Control and Assurance Manual (AQCAM) attested by DGCA shall be followed.

Table 1 Requirement for Aviation Turbine Fuels, Kerosene Type, Jet A-1
(Clauses 3.2.2, 3.2.3.1, 3.2.6, 3.3)

Sl No.	Characteristic	Requirement		Method of Test, Ref to [P:] of IS 1448/ASTM/IP/ISO
(1)	(2)	(3)		(4)
i)	<i>Appearance:</i>			
	a) Visual appearance	Clear, bright and visually free from solid matter and undissolved water at ambient fuel temperature		Visual (<i>see</i> Annex D)
	b) Colour	Report ¹⁾		P-14 / ASTM D 156* / ASTM D 6045
	c) Particulate contamination, at point of manufacture, mg/l, <i>Max</i>	1.0 ²⁾		ASTM D 5452*/IP 423
	d) Particulate, at point of manufacture, cumulative channel particle counts,	Channel counts	ISO Code ³⁾	IP 564*, IP 565 or IP 577
	1) $\geq 4 \mu\text{m(c)}$	Report	Report	
	2) $\geq 6 \mu\text{m(c)}$	Report	Report	
	3) $\geq 14 \mu\text{m(c)}$	Report	Report	
	4) $\geq 21 \mu\text{m(c)}$	Report	Report	
	5) $\geq 25 \mu\text{m(c)}$	Report	Report	
	6) $\geq 30 \mu\text{m(c)}$	Report	Report	
ii)	<i>Composition:</i>			
	a) Total acidity, mg KOH/g, <i>Max</i>	0.015		[P : 113]*/IP 354/ASTM D3242
	b) Aromatics, percent by volume, <i>Max</i>	25.0 ⁴⁾		[P : 23]*/ IP 156/ASTM D 1319
	or			
	Total Aromatics, percent by volume, <i>Max</i>	26.5		IP 436/ASTM D 6379*
	c) Total sulphur, percent by mass, <i>Max</i>	0.30 ⁵⁾		[P : 34] / ISO 8754/ASTM D 4294*
	d) Sulphur mercaptan, percent <i>m/m</i> , <i>Max</i>	0.0030 ⁶⁾		[P : 109]*/IP 342/ASTM 3227
	or			
	e) Doctor Test	Negative ⁷⁾		[P: 19]*/IP 30/ASTM D 4952
	f) Refining components, at the point of manufacture ⁸⁾			
	1) Non Hydro processed Components, percent v/v	Report		
	2) Mildly Hydro processed Components, percent v/v	Report		
	3) Severely Hydro processed Components, percent v/v	Report		
	4) Synthetic Components, percent v/v	Report		
iii)	<i>Volatility:</i>			
	a) Distillation:			[P : 18] ⁹⁾ /IP 123/ASTM D 86
	1) Initial boiling point, °C	Report		
	2) 10 percent recovery °C, v/v, <i>Max</i>	205.0		
	3) 50 percent recovery °C, v/v	Report		
	4) 90 percent recovery °C, v/v	Report		
	5) Final boiling point, °C, <i>Max</i>	300.0		
	6) Residue, percent v/v, <i>Max</i>	1.5		
	7) Loss, percent v/v, <i>Max</i>	1.5		
	b) Flash point (Abel), °C, <i>Min</i>	38.0		[P : 20] (Method B)/ISO 13736* / IP 170
	c) Density at 15°C, kg/m ³	775.0 to 840.0		[P:16]*/ IP 160 / ASTM D 4052

Table 1 (Concluded)

Sl No.	Characteristic	Requirement	Method of Test, Ref to [P:] of IS 1448/ASTM/IP/ISO
(1)	(2)	(3)	(4)
iv)	<i>Fluidity</i>		
	a) Freezing point, °C, <i>Max</i>	–47	[P : 11]* /IP 16/ASTM D 2386
	b) Kinematic viscosity at minus 20°C, mm ² /s, <i>Max</i>	8.000	[P : 25]*/ IP 71/ASTM D 445
v)	<i>Combustion:</i>		
	a) Specific energy ¹⁰⁾ MJ/kg, <i>Min</i>	42.80	[P : 6] / ASTM D 3338*
	b) Smoke point, mm, <i>Min</i> or	25.0	[P : 31]/ IP 598 ¹¹⁾ */ASTM D 1322
	1) Smoke point, mm, <i>Min</i> and	18.0	[P : 31] ¹¹⁾ / IP 598 ¹¹⁾ * /ASTM D 1322
	2) Naphthalenes, percent v/v, <i>Max</i>	3.00	[P : 118]* /ASTM D 1840
vi)	<i>Corrosion:</i>		
	a) Copper strip corrosion for 2 h at 100°C	Not worse than No. 1	[P : 15]* / IP 154/ASTM D 130
	b) Silver strip corrosion ¹²⁾	“0” at Refinery	Annex B
	classification, for 4 h at 50°C, <i>Max</i>	“1” at Delivery Point	
vii)	<i>Thermal Stability, JFTOT at Control Temperature of 260°C</i>		
	a) Filter pressure differential, mm Hg, <i>Max</i>	25	[P : 97] / IP 323 /ASTM D3241*
	b) One of the following requirement to be met	Less than 3, No ‘Peacock’ (P) or	
	1) Tube rating, visual (VTR)	‘Abnormal’ (A)	Note 13 and 14
	2) Annex C ITR or Annex D ETR, average over area of 2.5 mm ² in nm	85 max	
viii)	<i>Contaminants:</i>		
	Existent gum, mg/100 ml, <i>Max</i>	7	[P : 29] ¹⁵⁾ / IP 540/ASTM D 381
ix)	<i>Water Separation Characteristics:</i>		
	a) Water reaction: Interface rating ¹⁶⁾ , <i>Max</i>	1b	[P : 42]
	b) Micro-separometer rating ¹⁸⁾ at the point of manufacture:		[P : 142] ¹⁷⁾ */ ASTM D 3948
	1) MSEP without SDA, <i>Min</i>	85	
	2) MSEP with SDA, <i>Min</i>	70	
x)	<i>Conductivity:</i>		
	Electrical conductivity, pS/m ¹⁹⁾	50 - 600	ISO 6297*/IP 274/ ASTM D 2624
xi)	<i>Lubricity:</i>		
	Wear scar diameter, mm, <i>Max</i>	0.85 ²⁰⁾	ASTM D 5001
xii)	<i>Identified Incidental Materials</i>		
	Fatty Acid Methyl Ester, mg/kg, <i>Max</i>	50 ²¹⁾	IP 585* or IP 590 (see Note 22)

* Denotes referee method in the above table

NOTES :

1 The requirement to report Saybolt Colour shall apply at point of manufacture, thus enabling a colour change in distribution to be quantified. Where the colour of the fuel precludes the use of the Saybolt Colour test method, then the visual shall be reported. Unusual or atypical colours should also be noted. For further information on the significance of colour (see Annex C).

2 Refer to the information on particulate contamination in Annex D.

3 Both number of particles and number of particles as a scale number as defined under Table 1 of ISO 4406 : 1999 shall be reported.

4 Defence requirements to be met at 22 percent by volume, maximum.

5 Defence requirements to be met at 0.25 percent total Sulphur, maximum.

6 Defence requirements to be met at 0.002 percent by mass, maximum.

7 The alternative requirement e) is a secondary requirement to d). In the event of a conflict between sulphur mercaptan (d) and Doctor Test (e) results, requirement d) shall prevail.

8 Each Refinery component used in the make-up of the batch shall be reported on the Refinery Certificate of Quality as a percentage by volume of the total fuel in the batch. Mildly hydro processed components are defined as those petroleum derived hydrocarbons that have been subjected to a hydrogen partial pressure of less than 7000 kPa (70 bar or 1015 psi) during manufacture. Severely hydroprocessed components are defined as those petroleum derived hydrocarbons that have been subjected to a hydrogen partial pressure of greater than 7000 kPa (70 bar or 1015 psi) during manufacture. The total of non-hydroprocessed plus mildly hydroprocessed plus severely hydroprocessed plus synthetic components shall equal 100 percent.

9 In method [P : 18], all fuels certified to this specification shall be classed as group 4 with a condenser bath temperature of 0 to 4°C.

10 Specific energy by one of the calculation methods listed under Annex 'G' will be acceptable. Where a measurement of specific energy is deemed necessary, the method to be used shall be agreed between the purchaser and supplier.

11 The automated method in IP598 is the referee method.

12 Defence requirement. IP : 227-1999 to be followed till a new test method is prepared.

13 The annexes referred to in Table 1 and this note correspond to those in IP323. If the technically equivalent ASTM D3241 test method is used, the same protocol shall be followed using the appropriate annex that corresponds to the visual (VTR), interferometric (ITR) or ellipsometric (ETR) method. Tube deposit ratings shall be measured by IP323 Annex C ITR or Annex D ETR, when available. If the Annex C ITR device reports "N/A" for a tube's volume measurement, the test shall be a failure and the value reported as >85 nm. Visual rating of the heater tube shall be by the method in IP323. Annex B is not required when Annex C ITR or Annex D ETR deposit thickness measurements are reported. In case of dispute between results from visual and metrological methods, the metrological method shall be considered the referee.

14 Examination of the heater tube to determine the visual tube rating using the visual tube rater or deposit thickness by ETR or ITR shall be carried out within 120 min of completion of the test.

15 Air may be used instead of steam as the evaporating medium so long as the temperatures remain as specified in [P : 29] of IS 1448, Table 1 'Test conditions for aviation turbine fuel for steam jet apparatus'. When carrying out this procedure, air flow calibration should be adjusted to give an air flow of 600 ml/s at ambient conditions. The beaker should still undergo the same pre-heating as in steam jet procedure

16 Whenever MSEP is reported this test need not be carried out.

17 If the sample contains sediment or insoluble matter, it shall be allowed to stand and clear fuel decanted for testing. The sample shall not be filtered.

18 These MSEP requirements apply only at the point of manufacture. No precision data are available for fuels containing SDA. If MSEP testing is carried out during downstream distribution no specification limits apply and results are not to be used as the sole reason for rejection of a fuel. Where SDA is added at point of manufacture the MSEP limit of 70 shall apply. No precision data are available for fuels containing SDA; if MSEP testing is carried out during downstream distribution no specification limits apply and the results are not to be used as the sole reason for rejection of a fuel. A protocol giving guidelines on possible actions to be taken following failed MSEP testing can be found in the Joint Inspection Group's Bulletin Number 65, MSEP Protocol at 'www.jigonline.com' under 'fuel quality'. Where SDA is added downstream of point of manufacture, it is acknowledged that MSEP results may be less than 70.

19 The conductivity limits are mandatory for product to meet this specification. However it is acknowledged that in some manufacturing and distribution systems it is more practical to inject SDA further downstream. In such cases the Certificate of Quality for the batch should be annotated thus: "Product meets requirements of IS 1571 except for electrical conductivity". The Specification Authority is also aware of situations where conductivity can decrease rapidly and the fuel can fail to respond to additional dosing of Stadis 450 (refer Annex H of DefStan 91 -091 issue 9 for more information).

20 Defence requirements to be met at 0.65 mm, *max*. Irrespective of method of production of ATF, that is, Hydrotreated, sweetening process or mixed, lubricity in terms of WSD shall be reported in the Test Reports. If 'as is' WSD of ATF is greater than 0.65 mm at the point of production at the refinery, the desired WSD shall be obtained at the refineries after doping with the approved lubricity additive as mentioned in 3.2.4 and the quantity thus required to obtain WSD < 0.65 mm shall be annotated in the batch test reports. If the quantity of LIA required for any of the batches of ATF at the refineries is found to be more than the stipulated maximum of the respective LIA as given in 3.2.4.2, then such batches of ATF shall not be supplied by the refineries nor utilized by the defence. For the batches of ATF of WSD > 0.65 mm, doping of optimized quantity of respective LIA stipulated by CEMILAC shall be mandatorily undertaken just before ATF is inducted into the aircraft. All activities of compliance in respect of doping and maintenance of relevant records for traceability point of view shall be vested solely by the supplier of ATF namely, AFS.

21 See E-5 of Annex E and F-4 of Annexure F for additional information on identified incidental materials and FAME. On an emergency basis, up to 100 mg/kg FAME is permitted in jet fuel when authorized by the airframe and engine manufacturers and managed in compliance with airframe and engine manufacturer requirements. An emergency basis can be defined as an unexpected and unforeseen situation that requires prompt action. For example where FAME contamination has been introduced into part of an airport distribution system where it cannot be quickly segregated or isolated for remediation without halting airport refuelling operations. All such instances should be raised through the procurement authority, duty holder or aircraft operator.

22 Post manufacture a risk assessment shall be undertaken to quantify the potential risk of FAME carryover in all supply chains. Where such assessments indicate that there could be a potential risk in jet fuel supplies, additional quality assurance procedures shall be introduced to increase control in order to mitigate the risk. Where the risk of FAME carryover exists and it is not possible to control with additional quality assurance procedures, testing shall be instigated. Further guidance on how to verify compliance with this requirement is contained in Annex F.

The RCQ/COQ shall state. "Not measured, Risk assessed in accordance with JIG bulletin 106 against the FAME result in the specification requirement".

23 All test methods referred to in this standard include a precision statement. The interpretation of results based on test method/precision shall be used whenever applicable. In case of dispute the procedure described in ISO 4259 shall be used.

ANNEX A

(Clause 3.2.4.1)

AVIATION TURBINE FUEL LUBRICITY

(Informative)

A-1 Aircraft/engine fuel system components and fuel control units rely on the fuel to lubricate their moving parts. The effectiveness of a jet fuel as a lubricant in such equipment is referred to as its 'lubricity'. Differences in component design and materials result in varying degrees of equipment sensitivity to fuel lubricity. Similarly, jet fuels vary in their level of lubricity. In-service problems experienced have ranged in severity from reductions in pump flow to unexpected mechanical failure leading to in-flight engine shutdown.

A-2 The chemical and physical properties of jet fuel cause it to be a relatively poor lubricating material under high temperature and high load conditions. Severe hydro processing removes trace components resulting in fuels which tend to have a lower lubricity than straight-run or wet-treated fuels. Lubricity improver additives are widely used in military jet fuels. They have been used occasionally in civil jet fuel to overcome aircraft problems, but only as a temporary remedy while improvements to the fuel system components or changes to fuel were achieved. Because of their polar nature, these additives can have adverse effects on ground-based filtration systems and on fuel/water separation characteristics.

A-3 Some modern aircraft fuel system components have been and are being designed to operate on poor

lubricity fuel. With the participation of the international aviation industry the SAE AE-5B group has revised the procedure for the low lubricity endurance test for aircraft engine fuel pumps, ARP 1797. The procedure now specifies that the test fluid used shall produce a wear scar diameter (wsd) between 0.85 and 0.96 mm as measured by ASTM D 5001. The introduction of a lubricity requirement maximum of 0.85, mm wsd is to provide a limit to the fuel lubricity which attempts to ensure that future equipment proven against ARP 1797 procedure does not suffer lubricity related problems in use. The requirement only applies to fuels containing more than 95 percent hydro processed material. where at least 20 percent is severely hydro processed. All the fuels which have caused problems have been in this category. It has been noted that not all fuels containing severely hydro processed components produce a wsd greater than 0.85 mm and this has been taken into account in setting the requirement.

A-4 There are older fuel system components still in use which are more sensitive to fuel lubricity. In these cases the aircraft operator should consult with the equipment manufacturer and fuel supplier to determine the best course of action which may induce the use of an approved lubricity additive to enhance the lubricity of a particular fuel, a measure which is already permitted by the standard.

ANNEX B

[Table 1, Sl No. (vi) b)]

DETERMINATION OF CORROSIVENESS TO SILVER OF AVIATION TURBINE FUELS —
SILVER STRIP METHOD (ADOPTED FROM IP 227 / 99)**B-1 SCOPE**

The test procedure specifies a method for the determination of the corrosive tendencies towards silver, of aviation turbine fuels. The result is classified as an integer in the range 0 to 4.

B-2 DEFINITION

For the purposes of this standard, the following definition applies.

B-2.1 Silver Corrosion

The corrosiveness of a sample, on a silver strip specimen, measured visually on a scale of 0 to 4.

B-3 PRINCIPLE

A polished silver strip is completely immersed in 250 ml of fuel at $50^{\circ}\text{C} \pm 1^{\circ}\text{C}$ for a period of 4 h. At the end of this period the silver strip is removed from sample, washed and evaluated for corrosion.

B-4 APPARATUS**B-4.1 Test Apparatus**

Comprising the following (*see* Fig. 1).

B-4.1.1 Test Tube

350 ml capacity, made of heat-resistant amber glass and fitted with an amber glass B45 ground glass socket.

NOTE — Clear glass test tubes may be used provided light is excluded from the sample.

B-4.1.2 Cold-finger Condenser

Fitted through a B45 stopper such that an 85 mm length of the condenser is immersed in the fuel. The condenser shall be fitted with a glass hook from which the cradle is suspended. If more than one apparatus is in use, the condensers shall be connected in parallel so that each condenser has a similar efficiency. The inlet water temperature shall be controlled so that it does not exceed 25°C .

B-4.1.3 Glass Cradle

For suspension of the silver strip in the fuel such that the top of the strip is 25.0 mm to 30.0 mm below the bottom of the condenser.

B-4.2 Water Bath

Capable of maintaining the tube and its contents at a temperature of $50^{\circ}\text{C} \pm 1^{\circ}\text{C}$. The bath shall be fitted with a lid having holes to accommodate the test tubes.

B-4.3 Strip Vice

For holding the silver strip firmly without marring the edges.

NOTE — The type specified in ISO 2160, ASTM D130, IP 154 and BS 2000 : Part 154, is suitable.

B-4.4 Thermometer

Capable of indicating the temperature of the bath within the limits stated in **B-4.2** when immersed to its designated immersion. [Range -20 to $+102^{\circ}\text{C}$ (LC -0.2°C)].

NOTE — Thermometer of ASTM 12 C or IP 64 C grade can also be used.

B-4.5 Stainless Steel Forceps**B-5 REAGENTS AND MATERIALS**

B-5.1 Silver strip, assaying at 99.9 percent (m/m) Ag minimum and of length 17.0 mm to 19.0 mm, width 12.5 mm to 12.7 mm, and thickness 2.5 mm to 3.0 mm.

B-5.2 Polishing materials, silicon carbide cloth of varying degrees of fineness including nominal 53 μm (240 grade); also a supply of nominal 105 μm silicon carbide grain and pharmaceutical grade absorbent cotton wool.

B-5.3 Filter paper, medium fast to fast.

B-5.4 2,2,4-trimethylpentane (isooctane) of minimum 99.75 percent purity is the referee solvent, but any volatile sulphur-free hydrocarbon solvent that shows no tarnish when tested by the procedure of this standard is suitable.

B-6 SAMPLING

Unless otherwise specified, the samples shall be taken by the procedures specified in ISO 3170. The bottle shall be fitted with an impervious gas tight closure and closed immediately after filling. The volume of the sample drawn shall be such that a maximum ullage of 5 percent remains in the container after filling.

B-6.1 Sample Handling

Keep the sample cool whilst being transported and stored.

NOTE — A maximum temperature of 4°C is recommended.

The sample shall be tested as soon as is practical after sampling and tested immediately after opening the sample container.

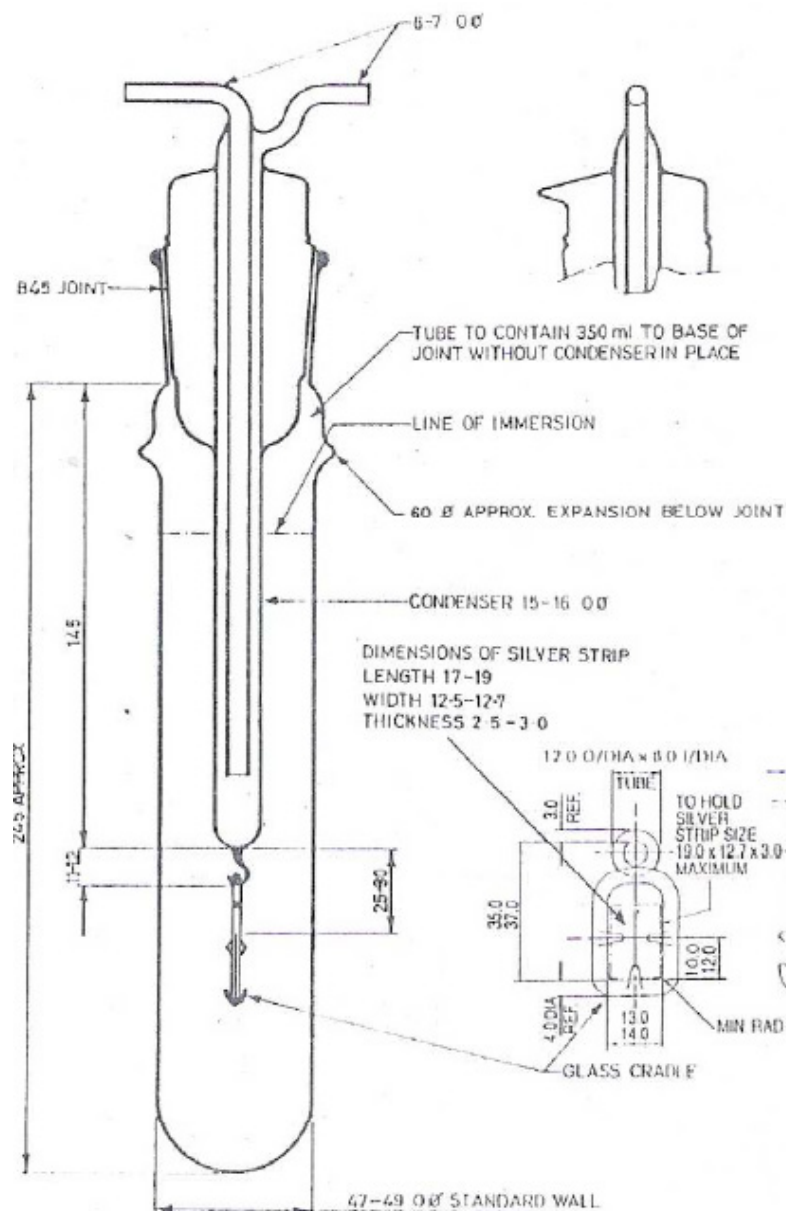


FIG. 1 TEST APPARATUS

If suspended water (haze) is observed in the sample, obtain in alternative clear sample.

B-6.2 Apparatus Preparation

B-6.2.1 Do not use silver strips whose edges show wear (elliptical surfaces). Remove all surface blemishes from all six sides of the silver strip with silicon carbide cloth sufficiently fine to accomplish the desired results. Finish with nominal $53\ \mu\text{m}$ (240 grade) silicon carbide cloth removing all marks that may have been made by other grades of cloth. Immerse the strip in the 2,2,4 – trimethylpentane, from which it shall be withdrawn when proceeding to the final polishing step.

B-6.2.2 As a practical manual procedure for surface preparation, either place a sheet of the abrasive cloth on a flat surface, moisten it with the 2,2,4 – trimethyl pentane, and rub the strip against the cloth with a rotary motion, protecting the strip from alternatively, prepare the strip mechanically, using appropriate grades of cloth.

B-6.2.3 Remove a strip from the 2,2,4 – trimethyl pentane. Holding it in the fingers protected with filter-paper, polish the ends and then the sides with the nominal $105\ \mu\text{m}$ silicon carbide grains picked up from a clean glass plate with a pad of cotton wool moistened with a drop of the 2,2,4 – trimethyl pentane.

Wipe vigorously with fresh pads of cotton wool and subsequently handle only with stainless steel forceps; do not touch with the fingers. Clamp in the vice and polish the main surfaces with the silicon carbide grains on cotton wool. Rub in the direction of the long axis of the strip, carrying the stroke beyond the end of the strip before reversing the direction. Clean all metal dust from the strip by rubbing vigorously with clean pads of cotton wool until a fresh pad remains unsoiled. Immerse the strip in the sample within 1 min of completing the final polishing.

NOTES:

1 It is important to polish the whole surface of the strip uniformly to obtain a uniformly stained strip. The use of a vice facilitates uniform polishing.

2 Contact of the silver strip with water before, or after, completion of the test run, will cause staining, making it difficult to evaluate the strip.

B-7 PROCEDURE

B-7.1 Pour 250 ml of the sample into the clean test tube. Suspend a freshly polished strip from the hook on the condenser by means of the glass cradle. Carefully lower the strip and condenser into the sample.

B-7.2 Place the tube in the water bath and maintain the temperature at $50^{\circ}\text{C} \pm 1^{\circ}\text{C}$ for 4 h. During the test period, run water through the condenser at a temperature not exceeding 25°C and at a rate of 10 ml/min to induce thermal stirring. At the end of the test period remove the strip from the tube and immerse it in 2,2,4 – trimethyl pentane. Withdraw the strip immediately, dry it with filter paper (by blotting not wiping), and inspect it for evidence of corrosion.

Silver Strip Classification

<i>Classification</i>	<i>Designation</i>	<i>Description</i>
0	No tarnish	Identical to a freshly polished strip, but may have some very slight loss of luster
1	Slight tarnish	Faint brown or white discoloration of strip
2	Moderate tarnish	Peacock colours such as blue or mauve or medium/dark straw or brown coloration

<i>Classification</i>	<i>Designation</i>	<i>Description</i>
3	Slight blackening	Spots and patches of black or grey on surface or uniform thin film of black deposit
4	Blackening	Uniform heavy blackening with or without scaling

B-8 EXPRESSION OF RESULTS

B-8.1 Interpret the corrosiveness of the sample by comparing the appearance of the test strip with a freshly polished one to give a classification based on that given in Table 1. All surfaces, including the edges, shall be taken into account.

B-8.2 The ASTM colour standard for the thermal oxidation stability of turbine fuels (ISO 6249/IP 323/ ASTM D 3241) shall be used to differentiate between the brown colorations mentioned in classifications 1 and 2. Any brown coloration less than ASTM No. 4 shall be rated classification 1.

B-9 REPORT

The test report shall include:

- The type and identification of the product tested;
- A reference to this standard;
- The result of the test (**B-8**);
- Any deviation, by agreement or otherwise, from the standard procedures specified; and
- The date of the test.

B-10 PRECISION

The precision of this method is as follows:

- Repeatability, $r = 0$; and
- Reproducibility, $R = 1$.

The precision values, as defined in ISO 4259 /BS 4306 : 1992/IP 367, have been obtained by statistical examination of inter-laboratory results. (9 laboratories on 5 samples covering the results range 0 to 3), and were first published in 1971. A precision evaluation report is held at the Institute of Petroleum.

NOTE — In deriving these precision values, it was assumed that all the variability in the results reflected the precision of the method and was not due to any change in the samples between tests.

ANNEX C

(Table 1, Sl. No. i) a), Footnote 1)

SAYBOLT COLOUR

C-1 Colour can be a useful indicator of fuel quality. Darkening of fuel or a change in fuel colour may be the result of product contamination or instability.

C-2 Changes in Saybolt Colour from the original certificate of quality for the batch would usually be cause for investigation as follows:

<i>Initial Saybolt Colour at Point of Manufacture</i>	<i>Significant Change</i>
> 25	> 8
≤ 25 but ≥ 15	> 5
< 15	> 3

C-3 Normally fuel colour ranges from water white (colourless) to a straw/pale yellow. Other fuel colours may be the result of crude oil characteristics or refining process. If unusual colours are produced at the point of manufacture, this should be noted on the batch certificate to provide information to downstream users. Unusual colours such as pink, red, green or blue that do not significantly impact the Saybolt Colour number should also be investigated to the cause.

ANNEX D

(Table 1, Footnote 2)

INFORMATION ON SAMPLING AND PARTICULATE CONTAMINATION

(Informative)

D-1 The visual appearance of the product is a good indication of contamination and remains a key requirement for fuel throughout the distribution system. However, interpretation of the appearance requirement can lead to problems due to the subjective nature of the visual assessment. Therefore, a quantitative limit has been established for particulate contamination. A maximum particulate contamination of 1.0 mg/l, when tested to IP 423/ASTM D 5452, shall apply at point of manufacture only.

D-2 Fuels containing visual particulate or with particulate levels greater than 1.0 mg/l will require additional handling procedures, such as extended settling and/or filtration.

D-3 Where fuel is being delivered into aircraft, the IATA Guidance Material for Aviation Turbine Fuels Part III — Cleanliness and Handling, shall be referred to for appropriate information on contamination limits.

D-4 It is the intent of the specification authority to extend particulate contamination limits throughout the distribution system at a later date.

D-5 It is well known that free water can precipitate from jet fuel on cooling, therefore it can be

important to assess the visual appearance of the fuel at the ambient temperature of the fuel at the time of sampling. Samples transported within a location, for example, refinery tanks to a refinery laboratory should be assessed for visual appearance without delay to avoid any temperature variations between the laboratory and the tank. Thermostatically controlled oil or water baths can be used to maintain samples at the tank temperature, where delay in assessing visual appearance is unavoidable. If the samples are cooled significantly during transport from the tank to the certifying laboratory, typically occurring during air freight, there is a significant potential for water precipitation. This would in principle, constitute a failure of the visual appearance requirement. In such cases, it is permissible for the tank to be released by a competent person based on the tank side visual appearance of representative samples fully meeting the requirements of this specification. The tank release note should be annotated with the comment “tank side sample visual appearance clear, bright and visually free from solid matter and undissolved water. Appearance of undissolved water in laboratory samples attributed to cooling during transport.” This exception is only valid where samples sent to the laboratory fail solely on the appearance of free water.

ANNEX E

(Foreword)

QUALITY ASSUARANCE

E-1 Aviation fuel quality assurance is based on two key concepts: batches and traceability. A batch of fuel is defined as a distinct quantity of jet fuel that can be characterized by one set of test results. It is essential that refineries ensure batches are homogenous so that test results are representative of the product supplied.

Homogenous is defined as the density not varying by more than 2.5 kg/m³ across the batch.

E-2 At point of manufacture, the refinery shall issue a Certificate of Quality to certify that the batch of fuel complies with all of the requirements of this standard. The certificate shall cover not only the quantitative Table 1 limits but also all other requirements set out in the main sections and annexes of this standard.

E-3 To certify compliance with Table 1 limits, representative samples shall be drawn using appropriate procedures such as those outlined in IS 1447. Each homogeneous batch of the finished product shall be tested against the requirements of Table 1. Results shall be reported on the appropriate batch certificate of quality. This requirement is not satisfied by averaging on-line analysis results.

E-4 The minimum requirements for information to be shown on the fuel's batch test certificate of quality at point of manufacture are as under:

- a) Specification name, issue and any amendment number;
- b) Name and address of testing laboratory;
- c) Batch number or unique identifier;
- d) Quantity of fuel in the batch;
- e) Properties tested including specification limit, test method and result of test;

- f) Additives, including qualification reference and quantity added;
- g) Name and position of authorised test certificate signatory or electronic signature; and
- h) Date of certification.

Documentation shall be provided by the supplier to the purchaser to show that the fuel meets the requirements of this standard and demonstrates traceability to point of manufacture. Upon request the technical authority or end user shall be provided with the documentation.

E-5 Jet fuel can come into contact with incidental materials during manufacture and distribution. In a refinery, processing materials might be carried over in trace quantities into aviation fuels and some have been known to cause operational problems in aircraft fuel systems. In distribution, bulk jet fuel is typically handled in non-dedicated systems such as multiproduct pipelines and marine vessels where contact with incidental materials is unavoidable. Appropriate management of change measures shall be used at manufacturing locations, distribution, and storage facilities to maintain product integrity.

E-6 Naphtha carried by tank wagon or pipeline prior to ATF Jet A-1, may affect the quality of ATF Jet A-1 being transported. Hence necessary precautions need to be taken to address this issue.

E-7 In systems where FAME contamination is physically prevented then there is no requirement for FAME testing. Examples are at the refinery and/or distribution network where Jet A-1 is positively segregated and isolated from FAME containing components.

ANNEX F

(Table 1, Note 22)

PRODUCT INTEGRITY MANAGEMENT

F-1 BACKGROUND

F-1.1 It is acknowledged that trace levels of incidental materials have always been present in jet fuels meeting this standard. Defining a zero level for these materials is not straightforward; particularly given that:

- a) Advances in analytical techniques continue to reduce the threshold detection levels of chemical species;
- b) There could be a wide range of incidental materials involved; and
- c) In most cases there are no data on their effects in aircraft systems to define a no-harm level.

F-1.2 It is therefore not possible for this standard to require detailed chemical analysis of each batch of aviation fuel beyond the requirements listed in this standard. Instead, manufacturing and distribution locations shall ensure that they have adequate quality assurance and management of change procedures in place to maintain product integrity.

F-2 MANUFACTURING

Experience has shown that refinery processing additives, such as corrosion inhibitors, might be carried over in trace quantities into aviation fuel during refinery production. In some cases, this has resulted in operational problems in aircraft fuel systems. Moreover, these additives can cause problems at levels which may not be detected by the standard specification testing detailed in Table 1. Changes in additive composition/manufacturing source or refinery processing conditions shall be subject to a formal risk assessment to ensure maintenance of finished product quality.

F-3 DISTRIBUTION

F-3.1 Upstream of airport storage, bulk jet fuel is typically handled in non-dedicated systems such as multiproduct pipelines and marine vessels. As a result, jet fuel will come into contact with non-jet fuel materials. Product integrity is assured by the application of documented QA procedures as set out in various industry standards such as EI/JIG 1530, EI HM 50, API 1543 and Joint Inspection Group (JIG) Standards. Any changes in the fuel handling systems should be subject to a formal risk assessment and management of change to ensure product quality is maintained.

F-3.2 Specific information on FAME is given in **F-4** below.

F-4 INFORMATION STATEMENT ON THE CARRYOVER OF FAME (FATTY ACID METHYL ESTER) IN TRACE QUANTITIES DURING TRANSPORTATION IN NON-DEDICATED SYSTEMS

F-4.1 When biodiesel containing FAME (Fatty Acid Methyl Ester) was first introduced into Multi Product Pipelines (MPPs) co-transporting jet fuel in 1995, trials conducted using the best available analytical methods at that time indicated no detectable trail back of the FAME component into following jet fuel batches. Pipeline sequencing operations were not altered based on these data. However, with significant advances in experimental analytical techniques, some evidence of very low level FAME was detected in interface samples in 2006 prompting both refinement of the analytical methods and a further controlled pipeline trial in 2007. This controlled trial demonstrated that low level trail back of the FAME component from biodiesel into a following jet fuel batch can occur at detectable levels. In the absence of reliable data on historical trace level FAME carryover in MPPs, the initial fuel supply industry advice required revision of the sequencing of batches of biodiesel and jet fuel by employing a non-aviation buffer material between the products.

F-4.2 The widespread mandated introduction of biodiesel has significantly increased the potential for trace amounts of FAME in jet fuel. This has presented a major challenge to the operators of fuel supply and distribution systems

F-4.3 Comprehensive background and advice for managing the risks of FAME and jet fuel in non-dedicated distribution systems are available in a number of JIG bulletins; Bulletin number 75 is the current document on FAME update. Bulletin numbers 15, 16, 20, 21 and 26 and 61 are not current but available for background/reference material only. These bulletins may be downloaded from 'www.jigonline.com'.

F-4.4 The maximum permitted level of 50 mg/kg of FAME is introduced as a result of the recommendation of the EI study "Joint Industry Project: Seeking Original Equipment Manufacturer Approvals for 100 mg/kg Fatty Acid methyl Ester (FAME) in Aviation Turbine Fuel" and the ASTM D4054-16 extensive testing programme. The aviation petroleum industry is working towards an approval of 100 mg/kg FAME in jet fuel under the guidance of the engine and airframe OEMs. FAME has been added to Table 1, Test 12, as an incidental material so that producers/suppliers shall monitor FAME levels to provide a level of confidence before consideration can be given to 100 mg/kg FAME level.

ANNEX G*(Foreword)***ALTERNATE TEST METHODS**

<i>Characteristic</i>	<i>Alternate Method of Test</i>
Appearance	ASTM D 4176 Procedure 1
Total sulphur	ISO 4260, ISO 14596, ASTM D 1266, ASTM D 1552, ASTM D 2622, ASTM D 5453, IP 107, IP 373, IP 447, IP 336, ISO 20846, ISO 20884
Flash point	ASTM D 56 (Note 2), IP 523, ASTM D3828
Density at 15°C	ISO 12185, ASTM D 1298, IP365, ISO 3675
Freezing point	IP 435/ASTM D 5972, IP 528, IP 529/ASTM D 7153, ASTM D 7154 IP16,
Specific energy	ASTM D 4809, IP 12, IP 355
Distillation	ASTM D 7345 (<i>see</i> Note 1), ISO 3405
Kinematic viscosity	ASTM D 7042 (<i>see</i> Note 2), ISO 3104
Smoke point	ASTM D 1322, ISO 3014
Cu strip corrosion	ISO 2160
JFTOT	ISO 6249
FAME	IP 583, D 7797, IP 599

NOTES

1 Results from Test Method ASTM D7345 shall be corrected for relative bias as described in Test Method ASTM D7345.

2 Test Method ASTM D7042 results shall be converted to bias-corrected kinematic viscosity results by the application of the correction described in Test Method ASTM D7042 for jet fuel at –20°C as described in the precision and bias section.

ANNEX H

BIBLIOGRAPHICAL REFERENCES

<i>International/ Other Standards</i>	<i>Title</i>
ISO 3014 : 1993	Determination of the smoke point of kerosene
ISO 3104: 1994	Petroleum products — Transparent and opaque liquids — Determination of kinematic viscosity and calculation of dynamic viscosity
ISO 4259 : 2006	Determination and application of precision data in relation to methods of test
ISO 4260 : 1987	Determination of sulfur content — Wickbold combustion method
ISO 4406 : 1999	Hydraulic fluid power — Fluids — Method for coding the level of contamination by solid particles
ISO 6297 : 1997	Determination of electrical conductivity
ISO 8754 : 2003	Determination of sulfur content — Energy-dispersive X-ray fluorescence spectrometry
ISO 12185 : 1996	Crude petroleum and petroleum products — Determination of density — Oscillating U-tube method
ISO 14596 : 2007	Petroleum products — Determination of sulfur content — Wavelength-dispersive X-ray fluorescence spectrometry
ISO 3675 : 1998	Crude petroleum and liquid petroleum products — Laboratory determination of density — Hydrometer method
ISO 3405 : 2011	Petroleum products — Determination of distillation characteristics at atmospheric pressure
ISO 2160 : 1998	Petroleum products — Corrosiveness to copper — Copper strip test
ISO 6249 : 1999	Petroleum products — Determination of thermal oxidation stability of gas turbine fuels — JFTOT method
ISO 20846 : 2011	Determination of sulphur content of automotive fuels ultra violet fluorescence method
ISO 20884 : 2004	Determination of sulphur content of automotive fuels wave length dispersive X fluorescence spectrometry
ASTM D56 (Note 2)	Standard Test Method for Flash Point by Tag Closed Cup Tester
ASTM D 86	Standard Test Method for Distillation of Petroleum Products at Atmospheric Pressure
ASTM D 156	Standard Test Method for Saybolt Color of Petroleum Products (Saybolt Chromometer Method)
ASTM D 445	Standard Test Method for Kinematic Viscosity of Transparent and Opaque Liquids (and Calculation of Dynamic Viscosity)
ASTM D 1266	Standard Test Method for Sulfur in Petroleum Products (Lamp Method)
ASTM D 1298	Standard Test Method for Density, Relative Density, or API Gravity of Crude Petroleum and Liquid Petroleum Products by Hydrometer Method
ASTM D 1322	Standard Test Method for Smoke Point of Kerosene and Aviation Turbine Fuel
ASTM D 1552	Standard Test Method for Sulfur in Petroleum Products (High-Temperature Method)
ASTM D 2622	Standard Test Method for Sulfur in Petroleum Products by Wavelength Dispersive X-ray Fluorescence Spectrometry
ASTM D 3241	Standard Test Method for Thermal Oxidation Stability of Aviation Turbine Fuels
ASTM D 3338	Standard Test Method for Estimation of Net Heat of Combustion of Aviation Fuels
ASTM D3828	Standard Test Methods for Flash Point by Small Scale Closed Cup Tester
ASTM D 4052	Standard Test Method for Density, Relative Density, and API Gravity of Liquids by Digital Density Meter

<i>International/ Other Standards</i>	<i>Title</i>
ASTM D 4057	Standard Practice for Manual Sampling of Petroleum and Petroleum Products
ASTM D 4176	Standard Test Method for Free Water and Particulate Contamination in Distillate Fuels (Visual Inspection Procedures)
ASTM D 4294	Standard Test Method for Sulfur in Petroleum and Petroleum Products by Energy Dispersive X-ray Fluorescence Spectrometry
ASTM D 4306	Aviation Fuel Sample Containers for Tests Affected by Trace Contamination
ASTM D 4809	Standard Test Method for Heat of Combustion of Liquid Hydrocarbon Fuels by Bomb Calorimeter (Precision Method)
ASTM D 5001	Standard Test Method for Measurement of Lubricity of Aviation Turbine Fuels by the Ball-on-Cylinder Lubricity Evaluator (BOCLE)
ASTM D 5452	Standard Test Method for Particulate Contamination in Aviation Fuels by Laboratory Filtration
ASTM D 5453	Standard Test Method for Determination of Total Sulfur in Light Hydrocarbons, Spark Ignition Engine Fuel, Diesel Engine Fuel, and Engine Oil by Ultraviolet Fluorescence
ASTM D 5972	Standard Test Method for Freezing Point of Aviation Fuels (Automatic Phase Transition Method)
ASTM D 6045	Standard Test Method for Color of Petroleum Products by the Automatic Tristimulus Method
ASTM D 7153	Standard Test Method for Freezing Point of Aviation Fuels (Automatic Laser Method)
ASTM D 7154	Standard Test Method for Freezing Point of Aviation Fuels (Automatic Fiber Optical Method)
ASTM D 7042	Dynamic Viscosity and Density of Liquids by Stabinger Viscometer (and the Calculation of Kinematic Viscosity)
ASTM D 7345	Distillation of Petroleum Products at Atmospheric Pressure (Micro Distillation Method)
ASTM D 7797	Determination of the Fatty Acid Methyl Esters Content of Aviation Turbine Fuel Using Flow Analysis by Fourier Transform Infrared Spectroscopy — Rapid Screening Method
IP 12	Determination of specific energy
IP 16	Determination of the freezing point of aviation fuels — Manual method
IP 107	Determination of sulphur — Lamp combustion method
IP 160	Crude petroleum and liquid petroleum products — Laboratory determination of density — Hydrometer method
IP 170	Determination of flash point — Abel closed-cup method
IP 323	Determination of thermal oxidation stability of gas turbine fuels
IP 336	Petroleum products — Determination of sulfur content — Energy-dispersive-X-ray fluorescence method
IP 355	Petroleum products — Estimation of net specific energy of aviation turbine fuels using hydrogen content data
IP 365	Crude petroleum and petroleum products — Determination of density — Oscillating U-tube method
IP 373	Determination of sulfur content — Oxidative microcoulometry method
IP 423	Determination of particulate contaminant in aviation turbine fuels by laboratory filtration

<i>International/ Other Standards</i>	<i>Title</i>
IP 435	Determination of the freezing point of aviation turbine fuels by the automatic phase transition method
IP 447	Petroleum products — Determination of sulfur content — Wavelength-dispersive X-ray fluorescence spectrometry
IP 523	Determination of flash point — Rapid equilibrium closed cup method (ISO 3679 : 2004)
IP 528	Determination of the freezing point of aviation turbine fuels — Automated fiber optic method
IP 529	Determination of the freezing point of aviation fuels — Automatic laser method
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